APPENDIX K. DESCRIPTIONS OF POTENTIAL MEASURES

This appendix provides brief draft descriptions of many potential measures for flood damage reduction and ecosystem restoration to be considered in the formulation of the Master Plan during Phase II of the Comprehensive Study. The descriptions were developed from document reviews, and from meetings for technical support, policy focus, and local support.

The measures in this appendix are listed in Table K-1.

TABLE K-1
POTENTIAL FLOOD DAMAGE REDUCTION AND ENVIRONMENTAL RESTORATION MEASURES

Flood Damage Reduction Measure	Environmental Restoration Measures
Flood Flow Regime ● Operate/Reoperate Reservoirs System Wide ● Utilize Water Delivery System to Store Floodwaters ● Establish/Expand Groundwater Recharge Areas to Disperse/Store High Flows ● Use Refuge/Wildlife Areas for Storage ● Incorporate Flood Water Storage Into Acquired or Easement Land Management ● Upstream Land Management to Reduce Erosion and Sediment Input to Reservoirs **System Capacity** ● Setback Levees - Major Setbacks ● Setback Levees - Minor Setbacks ● Back-up Levees ● Remove Flow Restrictions at Bridge Crossings ● Create or Restore Meanderbelt ● Channel Clearing **System Reliability** ● Strengthen Levees ● Repair Levees ● Abandon Levees ● Improve Levee Emergency Response ● Streamline and Consolidate Permitting Process for Levee Repair ● Establish Vegetation to Dissipate Wave Energy in Bypasses **Management of the Floodplain** ● Nonstructural Floodplain Management for Urban Areas ● Nonstructural Floodplain Management for Rural Areas ● Revise Floodplain Management Policy -- Mandatory Flood Insurance for Structures Subject to Residual Risk	● Re-forestation of Floodplain Corridors ● Protect Existing Natural Physical Processes ● Reestablish Suitable Hydrologic Regime to Restore Natural Physical Processes ● Restore Oxbows ● Restore Spawning Gravel - Replenish Gravel ● Restore Spawning Gravel - Upstream Land Management ● Remove Exotic Vegetation - Terrestrial ● Remove Exotic Vegetation - Aquatic ● Restore Gravel Pits ● County Protection of Stream Corridors ● Increase the Acreage of Seasonal Wetlands

Measure: Operate/Re-operate Reservoirs System-Wide

Background: During flood events, reservoirs with flood storage are operated to limit flows at index points downstream. These limiting flows are based on either preventing damages at the most vulnerable point downstream or on downstream leveed floodway capacities. These releases are not completely predicated on other reservoir releases in the system. Releases from reservoirs are often necessary in early fall to provide flood storage space for the coming flood season. These releases are done in a manner to safely lower the reservoir and do not completely evaluate their impact on downstream fish species. There is an opportunity to optimize both of these release efforts.

Description of Measure: This measure would develop an operational scheme and tool that would consider all index points and all reservoir releases in the system. This operational scheme would be optimized so that the maximum benefits would be provided to the system during a flood event. This measure would also investigate the conditions that limit flow at the index points and consider whether conditions could be modified to allow larger releases from the reservoir system. The ability to safely release larger flows during a flood event improves the system's ability to manage large storm events. Early fall flow needs for fish would be investigated to determine if early fall releases could be modified to enhance fish restoration without endangering the flood management purpose of the reservoir system.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Improve flood management of the systems
- Promote the stability of native species populations and recovery of threatened and endangered species in the flood management systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood management systems.

Benefits of the Measure: An optimized system approach to flood releases would provide greater overall flood damage reduction during a flood event. A tool to evaluate impacts of different release schedules would allow better informed and more timely release decisions during a flood emergency. Slight modifications to fall release schedules might aid the spawning or migration of endangered species. Releases might be ramped in such a way as to enhance geomorphic processes in the river systems.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Changes in flood release management would have to be done in a way that would not increase flooding in any area beyond the natural level. Obtaining flood storage prior to the flood season would be the paramount purpose. Releases for fishery management could impact this objective. Re-operation would also have to be done in a way to not reduce system water supply without just compensation.

Measure: Utilize Water Delivery System to Store Floodwaters

Background: The upper mainstem San Joaquin River at Friant Dam has been managed to divert all flows from the River by functioning as a diversion structure. Flood flows up to the capacities of the Madera and Friant-Kern canals are diverted both north and south to be dispersed on farmlands and/or captured in groundwater recharge areas. Dispersing flood flows reduces the volume and duration of flood flows, thus reducing potential flood damage and the magnitude of recommended flood protection measures downstream.

However, other basins do not maximize flood flow dispersion mechanisms to the extent that they are used in the Upper San Joaquin and Tulare basins.

Description of Measure: Divert flood water into existing water supply delivery canals and distribution facilities. Whenever possible, deliver water to groundwater recharge sites and, to the extent possible, distribute the remaining flood water on agricultural land throughout the basins. Determine the capability of flood water dispersion from the perspective of volume, timing, and magnitude of residual flood flows.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve system reliability
- Improve flood management of the systems

Benefits of the Measure: Using existing facilities to disperse a portion of flood flow volumes reduces the degree of flood protection measures to gain the same level of protection. Depending on the extent, timing, and location of flood dispersal groundwater recharge could occur.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): The magnitude of dispersal will be constrained by diversion capabilities and available canal capacities. Landowner participation to disperse flood flows would be on a willing participant basis. Canal owners and landowner compensation (easements?) may be recommended to urge participation. The presence of endangered and/or threatened species at the diversion point may preclude its use. Water contracts and water rights agreements may need modifications.

Measure: Establish/Expand Groundwater Recharge Areas to Disperse/Store High Flows

Background: There are areas in the Sacramento and San Joaquin River basins which are used for groundwater recharge. These existing groundwater recharge basins can be modified and new groundwater recharge basins developed to receive floodwaters from rivers and tributaries to reduce flooding along rivers and tributaries. Also, water stored in the groundwater basins can be used to exchange water supply storage space for flood control storage space in reservoirs. Application of this measure should be investigated throughout the study area.

Description of Measure: This measure calls for the development of new groundwater recharge basins or expansion of existing basins for use for flood control. During periods of excess flows in the rivers or tributaries, flood flows can be diverted to the groundwater recharge basins to reduce the peak flows and flood volumes. The stored groundwater could be exchanged for flood control storage space in reservoirs where needed.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve system reliability
- Improve flood management of the systems
- Increase operational flexibility

Benefits of the Measure: Diversion of floodflows could reduce peak flows and volumes in the channels. The amount of the peak flow attenuation and volume reduction would depend on the capability to recharge and capacity of the recharge basin, but is generally low in relation to peak flood flows on the rivers. The exchange of water stored in the groundwater basin for additional flood control storage space in selected reservoirs could increase the level of flood protection to areas at high risk of flooding. The overall benefit would be reduced flood threat to lives and property.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Groundwater recharge basins which can be used for receiving and storing floodwaters would need to be identified, necessary real estate rights acquired and the facility developed to receive, store, and infiltrate water to the underground storage basins. This will require the design and operation of the recharge basin under varying flow and water quality conditions. Land rights would have to be acquired for storing and spreading the floodwaters; these could be in fee title or as easements or joint-use with farming, grazing, wildlife habitat or other uses. In-place water exchange agreements with reservoir operators would facilitate the exchange of stored groundwater for flood control storage space in reservoirs with need for additional flood control storage space. Environmental analysis and compliance may be needed.

Measure: Use Refuge/Wildlife Areas for Storage

Background: There are numerous refuges and wildlife areas, existing and planned, adjacent to the rivers and tributaries. These areas are uninhabited, and could be used to store floodwaters temporarily during periods of high river flows to reduce the risk of flooding elsewhere along river and tributaries. Conjunctive use of the refuge and wildlife areas for flood management purposes could result in low cost means of reducing flood damages.

Although most refuges and wildlife areas are flooded during the usual flood periods, there are potentials for the refuges/wildlife areas to release waters prior to flood flow releases and subsequently to recapture the same volume of released water from flood releases. There are also thousands of acres in the Water Bird Agricultural Land Flooding Program which could be managed from a flood operation perspective.

Description of Measure: The purpose of this measure is to provide temporary storage for floodwaters on lands adjacent to the river and existing bypass facilities and thereby create immediate reductions in peak flows downstream from the diversion areas. Gated culverts would be installed through existing levees and existing channels, levees, and irrigation canals would be used to distribute the diverted floodflows to various wildlife refuges areas.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the system
- Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.
- Improve other beneficial uses related to flood damage reduction
- Reduce flood risk to lives and property
- Improve system reliability
- Reduce flood damages related to insufficient system capacity
- Allow for adapting the system management in response to changes over time

Benefits of the Measure: The diversion of flood flows from the river can reduce the peak flows in the channels. The amount of the peak flow attenuation would depend on the capacity and location of the refuge or wildlife areas. Water diverted in excess of the needs of the refuges and wildlife areas could, in addition to reducing flood damages along the river channel, be used to recharge the groundwater basins, leach salts and other dissolved minerals in adjacent agricultural lands, and provide water for environmental restoration and other use.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): This measure could require the construction of diversion structures to enable river flood waters to enter the refuge and wildlife areas. This would require the cooperation and coordination of the refuge and wildlife area operators so that the diversion can be accomplished in a manner compatible with the operation of the refuge and wildlife areas. The ability of the refuge and wildlife areas to release and store floodwaters would need to be evaluated and refuge management plans may need to be revised.

Measure: Incorporate Flood Water Storage into Acquired or Easement Land Management

Background: Acquired lands purchased from willing sellers can be managed in part to lessen flood volumes downstream by incorporating flood dispersal/temporary flood water storage as part of their management plans. The planned refuge acquisition lands in the San Joaquin Valley have incorporated flood management within the management plans. Recent easement agreements do not necessarily include flood water storage as a component.

Description of Measure: The measure is targeted at incrementally reducing downstream flood volumes to assist flood management.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve system reliability
- Improve flood management of the systems

Benefits of the measure: Using existing facilities as part of flood operations avoids part of the need to increase flood protection structures.

Physical, Operational, or Institutional Considerations (conflicts and resolutions):
The ability to use acquired lands and/or easements as a flood management tool needs to be evaluated.

Measure: Upstream Land Management to Reduce Erosion and Sediment Input to Reservoirs

Background: River and tributary flows into reservoirs begin upstream, in the upper watershed. To some extent, the sediment transport characteristics of these flows are influenced by the conditions of the upper watershed. Upstream land management practices can affect conditions in the upper watershed, which in turn can influence erosion and sediment deposition downstream.

Description of Measure: The measure is targeted at management of upstream land that contributes to erosion or sedimentation; current management practices would be altered or mitigated. A comprehensive, watershed approach would be necessary. Factors that affect sediment balance that could be addressed include such prior and ongoing activities as mining, roads, urbanization, dams, and various types of agricultural practices.

Objective(s) Addressed by Measure:
• Improve flood risk management throughout the systems
• Reduce flood risk to lives and property
• Improve system reliability
• Improve flood management of the systems

Benefits of the measure: Changes in upstream land management could reduce sedimentation or erosion. For examples, on-site detention of runoff developed by paved surfaces in the upper watershed for timber management actions or during urbanization of the upper watersheds could reduce peak flow rates, and thereby reduce erosion downstream; management of sediment disturbed in the process of road construction in the upper watershed could reduce sedimentation downstream; and restoration of upper watershed meadows can both attenuate peak flows and reduce downstream sediment loads.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Upstream land management is largely outside the jurisdiction of the Corps; in a single watershed it would likely involve Federal, State, local and private lands. Numerous Federal and State regulations exist to address land management. Local watershed management groups, in partnership with Federal and State agencies, have proved to be an effective instrument for implementing watershed management on a basin-by-basin level.

Measure: Major Levee Setbacks

Background: In certain areas, the river systems have been closely confined by levees. These levees are often placed in high energy reaches of the river, and are subject to erosion or damage during flood flows. These levees are protected from erosion by rock riprap on the river banks and on the levee. Riprap inhibits the establishment of riparian vegetation. Levee maintenance forbids large woody vegetation on these flood management levees. These narrowed levee reaches have low flow capacity. This capacity is closely monitored by the operating agencies and the people in the areas protected by these levees.

Description of Measure: The existing levee next to the river is removed. The levee material is used to rebuild the levee away from the river. The distance from the river varies and is best established by determining the optimum increase of floodway capacity and impacts to infrastructure behind the existing levee. The new levee would be designed and constructed to current levee stability requirements. It could also be constructed to the same level of protection or to an increased level of protection. The land between the river and the new levee would be more frequently flooded and could continue in its present land use. A portion or all of the new floodway land could also restore riparian or other natural floodplain habitat. Flood easements would be needed over the new floodway lands. Critical facilities would be either relocated or flood-proofed.

Set-back levees can increase capacity but this measure would involve removal of the existing levee. This action is not unanimously supported by the landowners behind the existing levee. They oppose the increase in flood risk for any of their land and prefer that the existing levee remain in place to provide historic levels of protection.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve system reliability
- Improve flood management of the systems
- Minimize system operation and maintenance
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood management systems.
- Increase and improve riparian, floodplain, flood basin, and riverine habitats throughout the river flood management systems using an ecosystem approach.

Benefits of the Measure: Major setback levees may greatly increase the capacity of a floodway to convey additional floodwaters and create additional floodplain storage. The magnitude of increase depends on the extent of levee setback. Flood protection provided by the flood management systems would therefore increase. Removal of the levee from next to the river would reduce maintenance costs and reduce the likelihood of damage during a major flood event. This measure provides space for additional riparian forest and ecosystem restoration. More frequent flooding and land use changes might initiate or hasten the restoration of riparian vegetation along the river and native floodplain vegetation in the area previously protected. This ecosystem restoration would aid the recovery of threatened and endangered species in the study area. It could allow the establishment of natural river processes which would create a more natural river environment with a diversity of habitat along the river.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): This measure may remove agricultural lands from production. Local landowners would need adequate compensation. The removal of a landowner from proximity to the river may impact riparian water rights of that landowner. These rights would require protection by law, or, if lost, be compensated in some manner. There is great cost involved in the acquisition of flood easements, water rights, and the relocation of impacted infrastructure.

Measure: Minor Levee Setbacks (or "Slab-on" Setbacks)

Background: In certain areas, the river systems have been closely confined by levees. These levees are often placed in high energy reaches of the river, and are subject to erosion or damage during flood flows. These levees are protected from erosion by rock riprap on the river banks and on the levee. Riprap inhibits the establishment of riparian vegetation. Levee maintenance forbids large woody vegetation on these flood management levees. These narrowed levee reaches have low flow capacity, and this capacity is closely monitored by the operating agencies and the people in the areas protected by these levees.

Description of Measure: Minor Levee Setbacks are useful where there is little need to increase floodway capacity and where there is minimal amount of space or land acquisition available. This type of levee consists of adding material to the land side of an existing levee to raise the levee and/or to enlarge the cross-section. The waterside portion of the embankment then assumes a primary purpose of habitat restoration but still retains the minimum cross section needed for flood protection. The existing levee material to the water side of the newly expanded levee is retained; shrubs and trees are allowed to establish themselves for ecosystem restoration. The newly expanded levee is maintained according to regulation to aid in inspection and flood fighting. The water side existing levee area becomes an ecosystem component; shrubs and trees are maintained to benefit fish and wildlife. Often in this alternative, if water side erosion has been a problem, additional material is added to the water side to form a berm just above summer low-water level where additional shrubs and trees, particularly "shaded riverine aquatic" habitat, can establish themselves. The toe of the berm is protected from erosion with rock.

Objective(s) Addressed by Measure:
- Improve system reliability
- Improve flood management of the systems
- Minimize system operation and maintenance
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Increase and improve riparian, floodplain, flood basin, and riverine habitats throughout the river flood management systems using an ecosystem approach.

Benefits of the Measure: A significant advantage of this measure is to separate maintenance requirements of the flood damage reduction levee from maintenance requirements of ecosystem restoration, thus avoiding expensive levee maintenance requiring removal of vegetation. If adequate material is added, the stability of the levee can be improved. If the levee is also raised during the addition of material, floodway capacity can be maintained or increased. Riparian habitats can establish themselves in a corridor that had been devoid of habitat and thus help to restore threatened and endangered species. Vegetation can provide the flood management levee with protection from erosion and may reduce maintenance costs.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): This measure will require real estate on the land side of the levee. Relocation of utilities and facilities would be necessary in some areas. If additional capacity is not provided by raising the levee, the establishment of extensive riparian vegetation can reduce the capacity of a confined floodway. If the vegetation becomes a part of the erosion protection, the survival of this vegetation would be necessary, increasing maintenance costs. If waterside erosion occurs, repairs could be costly and could have significant impacts on the remaining vegetation.

Measure: Back-Up Levee Setbacks

Background: In certain areas, the river systems have been closely confined by levees. These levees are often placed in high energy reaches of the river, and are subject to erosion or damage during flood flows. These levees are protected from erosion by rock riprap on the river banks and on the levee. Riprap inhibits the establishment of riparian vegetation. Sound levee maintenance forbids large woody vegetation on these flood management levees. These narrowed levee reaches have low flow capacity. This capacity is closely monitored by the operating agencies and the people in the areas protected by these levees.

Description of Measure: As with Major Levee Setbacks, a new levee is constructed at some distance from the river. However, in this case, the existing levee is not removed. The distance from the river varies and is best established by determining the optimum increase of floodway capacity and impacts to infrastructure due to construction of the new levee. The new levee would be designed and constructed to current levee stability requirements. It would provide increased levels of protection to the lands behind it above the level provided by the existing levee left in place. The existing levee would continue to be maintained. The land between the existing and the new levee would receive its historic level of protection and could continue in its present land use. A portion or all of the inter-levee land could be used for ecosystem restoration.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve flood management of the systems
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.

Benefits of the Measure: The advantage of this type of setback is to contain the more frequent smaller floods within the existing levee systems. This type of levee also provides added capacity and additional transient storage but does not require the added space to be used until a larger, more infrequent flood occurs. Impacts to flood peaks would depend on the amount of setback provided. The new set-back levee provides added protection to the lands behind it. This type of setback can also promote ecosystem restoration.

Physical, Operational, or Institutional Considerations (conflicts and resolutions):
Conveyance increases will not be as efficient as regular set-back levees because the existing levee left in place requires overflow. Maintenance costs would increase due to the addition of a new levee. Risk of flooding the lands between the two levees would be unchanged. Landowners may seek the additional flood protection being provided to landowners behind the new levee, and demand restitution. Ecosystem restoration will not be as successful as other approaches because frequency of flooding on the inter-levee lands would not increase and the levee left in place would remain barren of woody vegetation. Lands allowed vegetation may promote floodplain habitat, but it will not be the riparian habitat which is needed to provide higher quality habitat for endangered species.

Measure: Remove Flow Restrictions at Bridge Crossings

Background: Risk for flood damage has been increased by existing development and continued development in the conveyance systems.

State highway, county road, and railroad bridge crossings of the mainstem of the river systems, and crossings of the bypasses sometime restrict the flow in the flood control conveyance facilities. Backwater problems are the net result.

Description of Measure: For crossings which have insufficient conveyance capacity or cause unnecessary backwater effects (as identified in the modeling), raise, replace, or remove existing structures to eliminate these effects.

For the purposes of designated floodways, require that new crossings be constructed according to standards that prohibit constraints on conveyance capacity, and reduce backwater effects.

Riparian habitat, wetland habitat, shallow water habitat, and terrestrial habitats can be integrated into the downstream bridge approaches and in downstream adjacent areas which do not influence capacity of the systems to pass flood flows.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve flood management of the systems
- Improve system reliability
- Minimize system operation and maintenance

Benefits of the Measure: The flood management systems can more efficiently carry flood flows and thus lower the risk of flood damage if the step is taken to raise or replace existing structures which constrict flood flow conveyance capacity and increase velocities, or cause backwater problems. The flood management systems would be more reliable, and sedimentation and maintenance costs reduced once backwater effects are lowered on upstream levees, and downstream levee erosion is eliminated. The backwater and erosion are caused by flow constrictions created by undersized bridge crossings.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Bridge raising or replacements must be cost-effective, relative to the damage reduction potential and relative to other flood damage reduction measures. Public bridges to be raised or replaced would be financed through the flood management project. Private bridges to be raised or replaced would be financed by the owner. State, county, and local road bridge raising or replacements would be coordinated with the replacement and rehabilitation schedules of the appropriate agency. Temporary measures would be considered to address flood damage reduction until the final raising or replacement of the structure can be completed.

Probable construction impacts would require mitigation.

Measure: Create or Restore Meander Belt

Background: The magnitude, duration, and frequency (hydrology) and velocity (hydraulics) of streamflow, and the geologic conditions of the stream bed and banks determine to what extent the river channel moves within its floodplain. Streamflow, geology, and movement of the channel are the primary physical factors responsible for developing and maintaining riparian forests within the floodplains of rivers such as the Sacramento and the San Joaquin.

The channel moves by eroding its bed and banks in some areas and by depositing sediment in other areas. Erosion and deposition rates; and inundation extent, duration, frequency, and timing determine to a large extent the types, amounts, and growth rates of vegetation. The more types of vegetation, the more diverse is the riparian forest. Consequently, a more diverse array of fish and wildlife species would be expected. In addition, a greater degree of vegetation promotes greater populations of species.

Along the Sacramento and San Joaquin rivers, there are reaches in which channel movement has been reduced or halted by narrowing the floodplain with levees which are set on or close to the river bank. These levees slow or eliminate erosion by hardening the banks with large rock, thereby reducing the hydrology and hydraulics by dam operations. While the movements of all Central Valley streams, and associated riparian habitat and species, have been affected, significant reaches still support full or partial characteristics of a dynamic migration pattern, or meander belt.

Description of Measure: A meander belt is the corridor in which a river or stream channel migrates, or moves laterally, over time. Development of a meander belt entails providing for the migration or lateral movement of a river channel as it adjusts to balance erosion with deposition. Characteristics of the meander belt include the width of the corridor as well as the channel sinuosity and the rate of channel movement. These factors are functions of the hydrologic and hydraulic properties of flow which determine the capacity of the river to erode and deposit; they also determine channel bed and bank soil and geologic properties which also affect the rate and magnitude of migration.

Creating or restoring a meander belt on the Sacramento or San Joaquin Rivers could entail removal of levees and/or bank protection, and the acquisition of interest in the land within the meander belt. Incorporating simulated flood peaks into dam water release schedules and protecting or restoring gravel and sediment supplies may also be included in this measure.

Objective(s) Addressed by Measure:
- Reduce the risk to lives and property by improving system reliability.
- Minimize operation and maintenance requirements and associated costs of the flood management systems.
- Allow for adapting the management of the systems in response to changes over time.
- Compensate for unavoidable, adverse socio-economic, land-use, and ecosystem impacts associated with flood management.
- Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management systems using an ecosystem approach.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood damage reduction systems.
- Incorporate ecosystem restoration features into the design of Federal, State, and local elements of the flood management systems.
- Reduce flood damages related to insufficient system capacity.
- Reduce the impacts of past and current floodplain land use activities on hydrologic, geomorphic, and biological attributes of the river systems.

Benefits of the Measure: Restoration of a meander belt promotes the dynamic process of plant community succession. In addition to allowing for the various successional stages of the riparian forest, meander belts also result in such riparian habitat as shady and bare eroding banks, sloughs, side channels, riparian grasslands, and sand and gravel bars. Each habitat type serves a variety of needs of different groups of fish and wildlife species.

Restoration of a meander belt may also reduce the costs of levee maintenance if the levees are set back and the overall length is shortened. This approach benefits flood safety and reduces maintenance costs of flood protection by reducing the need for expensive rock riprap, and reducing the potential for levee breaches. This measure may also result in the relocation of damageable property from the floodplain. Restoration of a meander belt may also help to improve water quality.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Potential impacts resulting from restoring a meander belt include the conversion of agricultural land and the associated reductions in crop revenues and employment. This measure would focus on lands in this order: public lands, lands from willing sellers, and lands where levee length per acre of land protected is greatest. Continued agricultural practices could be provided for where practicable.

Measure: Channel Clearing

Background: In certain areas, the river system has had its capacity reduced due to large amounts of vegetation growth and/or due to sediment deposition. This reduced channel capacity increases the risk of flooding to floodplain areas next to the channel. If capacity is significantly reduced, reservoirs cannot operate as designed due to insufficient capacity for objective flows. The vegetation can also provide habitat for or aid the life cycle of special status species. Shaded riverine aquatic habitat is a valued resource of special concern for many resource agencies. Some exotic species of vegetation do not contribute significantly to the ecosystem and have been especially aggressive in growing and clogging waterways. Changes in flow regimes due to dam construction have aided the spread of vegetation and the deposition of sediment.

Description of Measure: This measure would involve the removal of vegetation and/or sediment from the channel of impacted river reaches. Removal would be done with mechanical equipment (bulldozers, drag lines, front end loaders) and disposed of in several different ways. The removal of certain exotics would receive special treatment because if not done properly, removal actions can aid the spread of these exotics. Other removed vegetation could be burned. The vegetation would not have to be removed in its entirety. Selective clearing could still increase capacity but would have a reduced impact on the existing ecosystem. Some clearing of vegetation could be done by hand. Some sediments removed from the channel could have commercial value and could be either given or sold to private interests for their use. Other sediments would have to be removed to disposal areas.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the system
- Reduce flood risk to lives and property
- Improve flood management of the system
- Promote the stability of native species populations.

Benefits of the Measure: Removal of vegetation and/or deposited sediment would increase the capacity of a river reach. This would allow lower elevations for flood flows and reduce the frequency of flooding for adjacent floodplains. Removal and control of exotic species could allow the restoration of native vegetation that would be more beneficial to the ecosystem.

Physical, Operational, or Institutional Considerations (conflicts and resolutions):
A program of sediment removal could require continuing maintenance of capacity by periodic removal of future deposition. This could be a significant cost. In-channel modifications can have significant impacts to aquatic organisms including threatened and endangered species and would be stringently regulated. Depending on type and location of vegetation removed, there could be significant impacts to water quality and the existing ecosystem. Resource agencies which have to permit either of these actions would closely examine these proposed actions and could refuse to issue the needed permits. Unless these measures were implemented in such a way as to minimize impacts or included adequate mitigation, the required resource agency approval might not be acquired.

Measure: Strengthen Levees

Background: Levees are earth embankments. Their structural integrity is a function of the embankment soil properties and geometry. Levees become saturated during prolonged periods of high river stages. They are also permeable. Structural problems develop with slope failure during saturation and with sinkholes developed when material is removed by high seepage velocities through the levee. As a levee becomes saturated, the weight of the soil increases. If slopes are too steep, gravity forces exceed resistance forces and masses of earth will slide out of the levee. If these masses are large, the levee cross section is reduced and will not be able to withstand the forces of the high river stages. Levee failure occurs. If the embankment soil is too permeable, seepage velocities will remove material from the levee embankment or foundation. Voids are created in or underneath the levee which can cause collapse of a section.

Description of Measure: Levees are strengthened to resist slope failure by adding material to widen the top width, flatten steep slopes, or both. A stability berm is sometimes constructed at the landside toe of the levee. Seepage can be controlled by constructing an impermeable barrier curtain (slurry wall) in the levee and/or its foundation. This curtain is constructed by trenching in the levee and backfilling with an impermeable slurry. It is important to have this curtain extend far enough into the foundation to contact a less permeable foundation material or to lengthen the seepage path enough to reduce seepage velocities. This curtain may be placed at the waterside toe, in the levee centerline or at the landside toe. Another approach to seepage control is to construct a drainage blanket and/or berm on the landside slope and toe of the levee, or to construct toe drains at the landside toe. A drainage blanket may require additional embankment material, the installation of drain rock blankets, filter fabrics, pipes, and pumps for construction. Material can be added on the waterside of a levee to increase stability.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Reduce flood risk to lives and property
- Improve system reliability

Benefits of the Measure: This measure increases the reliability of levee performance during passage of a large flood. Many levee failures occur due to lack of structural integrity.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Some of these measures would require real estate at the toe and may require the relocation of utilities and facilities. Slurry walls are a costly measure; if the levee is also used as a roadway, construction of the slurry wall will disrupt transportation. A drainage berm would require additional real estate and may require the relocation of utilities and facilities. Berms constructed on the waterside of levees can result in loss of habitat and public access for fishing and recreation. These impacts must often be mitigated. Where real estate is expensive, adequate real estate is not available, or relocations are extensive, slurry walls can be less disruptive or less expensive.

Measure: Repair Levees

Background: During high flood flows, levees become damaged by erosion, slope failures, sinkholes, and, if the flow is sufficiently excessive, overtopping. This damage can be severe enough to cause the levee to fail, flooding land and facilities once protected by the levee. The levee can also be weakened to the extent that it would be more susceptible to failure during the next flood event. After each damaging event, a decision to repair a damaged levee must be made. Often this decision is based on the benefits provided by the levee compared to the cost of repair. If the cost of repair is more than the benefits provided, sometimes the decision is to not repair the levee.

Description of Measure: This measure would eliminate the requirement of an economic analysis for a repair decision. All damaged levees would always be restored to their pre-flood event condition regardless of cost and benefit.

Objective(s) Addressed by Measure:
• Reduce flood risk to lives and property

Benefits of the Measure: The repair of all levees would continue to provide the historic level of flood protection realized by areas behind the levee. Their flood risk would not be increased due to non-repair of a damaged levee.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): This measure could dictate uneconomical investments into continuing levee repairs. It also prevents possible ecosystem restoration benefits by allowing present land use to continue on possibly marginal lands.

Measure: Abandon Levees

Background: Levees located in high energy areas of a river system often require excessive maintenance or frequent repair. This maintenance and repair can inhibit the establishment of riparian habitat in the vicinity of the levee. Before the next major maintenance or after a levee is damaged, an economic analysis could be performed which compares the cost of continued maintenance and/or repair of a levee to the benefits provided by the levee. If the cost of maintenance/repair exceeds the benefits, then a decision could be made to abandon this levee.

Description of Measure: Abandonment would mean no repairs would be made to a damaged levee and maintenance would cease. The decision could also include breaching the levee to allow historic flooding on once protected areas. Lack of maintenance and repair would most likely result in future breaches in the levee. The abandoned levee might be replaced by a new levee in a location that was less susceptible to flood damage. The new levee would be constructed so as to decrease the maintenance requirements or need for frequent repair.

Objective(s) Addressed by Measure:
- Improve flood risk management throughout the systems
- Minimize system operation and maintenance
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Increase and improve riparian, floodplain, flood basin, and riverine habitats throughout the river flood management systems using an ecosystem approach.
- Promote natural, dynamic hydrologic and geomorphic processes in the systems.

Benefits of the Measure: The high cost of maintenance and repair for levees in high energy areas of the river would be eliminated. The additional transient storage could reduce flood peaks. The amount of reduction would depend on the amount of transient storage created, and when this storage would be utilized during the flood passage. More frequent flooding and land use changes might initiate or hasten the restoration of riparian vegetation along the river and native vegetation in the area previously protected. This ecosystem restoration would aid the recovery of threatened and endangered species in the study area. It could allow the establishment of natural river processes which would create a more natural river environment with a diversity of habitat along the river.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Lack of levee protection could impact land use behind the levee. The type of crops grown could change or agricultural use might cease because of frequent flooding. Facilities in the protected area would either have to be relocated to areas of less flood risk or modified to accommodate more frequent flooding. The landowner could assert that they are entitled to the same degree of flood protection as had been historically provided. Consideration would be given as to whether the landowner(s) behind the levee is owed compensation for land use impacts from levee abandonment or levee breaching. Without appropriate easements, the owner could choose to repair or maintain the levee with private funds and thus prevent the realization of ecosystem restoration.

Measure: Improve Levee Emergency Response

Background: After the 1997 flood, criticism was voiced about response time to levee emergencies and the lack of coordinated effort in some areas during the emergency. It was not clear as to the chain of command, and the level of responsibility for each level of government, and how to handle requests for assistance. The procurement and delivery of emergency resources were not optimal. The Governor's 1997 FEAT Report discussed these concerns and proposed several initiatives to improve emergency response.

Description of Measure: Typical actions under this measure would include preparation and dissemination of guidelines to coordinate flood emergency operations; guidance to local maintaining agencies to prepare for flood emergencies as well as the stockpiling of emergency materials prior to the flood season. More attention would be given to coordination and training prior to the flood season to assure that all levels of government were aware of procedure and responsibilities. Many FEAT Report initiatives regarding emergency operations would be implemented.

Objective(s) Addressed by Measure:
• Improve flood risk management throughout the systems

Benefits of the Measure: The measure would enable all levels of government to respond quickly and efficiently to levee emergencies during a flood event. A more rapid response would attempt to prevent levee breaks and flooding of protected areas. Levee maintenance agencies would have better direction for their responsibilities and from whom they should request assistance. Better preparedness for levee emergencies is the overall objective.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Many actions in this measure have been implemented. Several sets of guidelines based on initiatives in the FEAT Report have been developed and disseminated. There was extensive coordination and preparation among government entities for the 1998 flood season, due largely to the recent 1997 flood event, extensive and persistent media coverage of the 1998 El Nino event, and concerns about El Nino flooding. The challenge is to engage the media and the public during winters without large flood events or potentials. Normal and less-than-normal water years tend to dim memories of flooding and, with memory loss, comes lack of concern and even apathy. Vigilance by all levels of government to maintain flood awareness and preparation will remain vital to effective flood fighting once the reality of a flood is again upon Californians.

Measure: Streamline and Consolidate Permitting Process for Levee Repair

Background: Permits to repair flood-damaged levees are required from various agencies at the State and Federal levels. The permitting process should be streamlined by developing an agreement among those agencies to obtain such. Repair would be expedited and costs reduced. Duplication of information and analysis needs to be eliminated. Consolidation of documentation requirements and agency review into one step would reduce time and effort and provide uniformity in enforcement of codes and standards.

Description of Measure: Permitting and consultation for levee repairs include environmental documentation in compliance with NEPA and CEQA; consultation and/or permits is/are required from no less than seven governmental agencies. A detailed checklist could be devised to encompass the full scope of Federal and State responsibilities. Specific and uniform guidance would be especially necessary for mitigation requirements for hydraulic impacts.

Objective(s) Addressed by Measure:
• Improve system reliability by streamlining the permitting processes for flood damage reduction, levee stabilization, and/or system maintenance activities.
• Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.

Benefits of the Measure: Uniformity in application of permit requirements, of code enforcement, and in mitigation for specific impacts; expediting and reducing the cost of levee repairs; and reduced cost by streamlining bureaucratic paperwork.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Agreement would be needed among the State and Federal agencies devise a streamlined permitting process. A MOA or other similar instrument, perhaps modeled after the proposed CALFED permit streamlining process, should be devised to catalog interagency agreements.

Measure: Establish Vegetation to Dissipate Wave Energy in Bypasses

Background: In wide expanses of open water, wind-generated waves can cause considerable bank and shoreline erosion. Wind-generated waves in flood bypasses, particularly very wide areas like the Yolo and Sutter Bypasses may affect the integrity of the flood management systems by eroding bypass levees. Wave height defines the incipient wave energy and is the dominant factor influencing erosion. Bank slope and wave period are also determining factors. Establishing a vegetative cover on levee slopes can help dissipate wave energy and protect levees.

Description of Measure: Select and establish appropriate plants to create a vegetative cover that will dissipate wave energy and protect levees at vulnerable locations in the bypasses. Carefully select plant species that are likely to respond well to conditions of the site such as soil and slope. Such plants should hold soils and dissipate wave energy, and survive under wave break and wave run-up conditions. Longer, denser herbaceous plants may be most useful where wave attack is likely to be severe; woody plants that are dense and shrubby are more likely than taller single stemmed trees to effectively dissipate wave energy. Select seeds, tubers/plugs, and pole cuttings from plants growing in the vicinity. Additional bioengineering techniques may be included to maximize immediate benefits or to increase the level of protection. These techniques include organic mats with or without imbedded plantings; coconut or rice straw rolls with or without imbedded plantings, willow bundles, etc.

Objective(s) Addressed by Measure:
- Reduce the risk to lives and property by improving system reliability.
- Improve other beneficial uses related to flood damage reduction.
- Increase and improve riparian, floodplain, flood basin, and riverine habitats throughout the flood management systems using an ecosystem approach.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the systems.
- Incorporate ecosystem restoration features into the design of Federal, State, and local elements of the flood management systems.

Benefits of the Measure: The establishment of a vegetative cover on vulnerable bypass levees could improve the reliability of a flood management system by protecting the levee slopes from wind-generated wave erosion. Routine and emergency maintenance costs for repairing erosion damage would decrease. The plant cover would also provide valuable riparian and upland habitat for fish and wildlife.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Depending upon the intensity and the duration of the wave action, plant survival may be low in the wave breaking zone. Developing an appropriate planting design for the bypasses could also be challenging because the water level, and thus the point of wave attack, is so variable. Repairs to erosion damage could be costly and could have significant impacts on the remaining vegetation. Dense vegetation can also impact the ability to properly inspect and flood fight. Planting of flood management structures might prevent effective control of rodents which dig into structures and contribute to failure.

Measure: Nonstructural Floodplain Management for Urban Areas

Background: Urbanization of California's floodplains has contributed to the spiraling costs of flood disasters. Many flood damage reduction projects, originally built to provide a specific level of protection, now provide less than their design due to a variety of changed conditions. This diminished flood protection presents a dilemma for communities that have developed beside them. Floodplain management practices have not always been implemented by State and Federal agencies when siting their facilities. Development in floodplains often occurs as a result of economic pressures. In the end, the public continues to put itself at risk by purchasing houses in these floodplains.

During the mid-1960's, Federal policy began to include nonstructural means of managing floodplains to reduce losses. Since that time, floodplain management practices incorporate more accurate methods to analyze and predict flooding. In addition, natural resources of floodplains have been valued, and cost-sharing has altered financial responsibilities.

Description of Measure: Nonstructural floodplain management is a strategy to avoid dangerous, costly, unwise use of the floodplain. Nonstructural floodplain management techniques modify susceptibility to flooding, flood damage, and disruption, or they modify the impact of flooding on individuals and the community. The techniques that modify susceptibility are regulation of land use within the floodplain; acquisition of floodplain land; relocation of structures from the floodplain to areas not susceptible to flooding; raising structures in the floodplain to an elevation higher than the flood water surface elevation; flood forecasting; alternative stormwater management techniques; and flood proofing structures within the floodplain. Techniques that modify flood impact include Federal flood insurance; publicizing residual risk; flood emergency measures such as evacuation; and postflood recovery (provisions of the Disaster Relief and Emergency Assistance Act of 1988). These measures are distinguished from structural methods such as dams, levees, and channels, designed to modify floods.

Objective(s) Addressed by Measure:
- Avoid or reduce potential future flood damages by publicizing residual flood risk throughout the flood management systems.
- Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.
- Compensate for unavoidable adverse socio-economic, land-use, and environmental impacts associated with flood management actions.
- Implement improved floodplain management policies consistent with recommendations made by the FEAT Task Force on Flood Plain Management.
- Improve other beneficial uses related to flood damage reduction.

Benefits of the Measure: Nonstructural floodplain management measures reduce the potential for future flood damages by modifying susceptibility to or impacts from flooding, flood damage, and disruption. Floodplain regulations have significantly moderated floodplain development and therefore the damage that would have occurred without the programs. Disaster preparedness efforts have proven very effective in reducing flood losses, especially the loss of life. Flood forecasting and warning systems have reduced flood losses, particularly the loss of life. The disaster assistance system provided by Federal, State, and local governments and by the private sector is efficient and adequate to provide relief to individuals and communities.

Nonstructural floodplain management measures can also provide opportunities to restore and preserve the natural and cultural resources of floodplains. Some local jurisdictions have moved toward programs that combine other community objectives with floodplain management. These multi-objective programs typically take two forms: greenway or river corridor projects, and community redevelopment projects.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Implementation of some nonstructural floodplain management measures must include compensation for adverse socio-economic or land-use impacts. Courts have upheld the constitutionality of floodplain management regulations, despite their impact on property values, because such regulations help protect public health and safety; because they may be part of wider government plans or programs that benefit the public in general (e.g., pollution controls or the National Flood Insurance Program); and because even privately owned water-based lands are subject to public trust and navigation servitudes. Land rights acquisition is not widely used to accomplish flood loss reduction, largely because of the high cost of land, lack of awareness of the many values of the floodplain, concern about excessive public ownership of land, and the challenges of unconstitutional takings. Relocation (permanent evacuation) is used less commonly than other options except in small, isolated sectors of nonconforming uses. A consequence of disaster assistance has been the tendency of individuals and communities, with very little countervailing guidance from governmental agencies, to use these funds to return themselves and their property to the hazardous, preflood condition. Because some nonstructural floodplain management measures provide opportunities for multiple benefits, all of the benefits for flood damage reduction and ecosystem restoration must justify the associated costs.

Measure: Nonstructural Floodplain Management for Rural Areas

Background: Economic losses from flooding, disruption of lives, and costly emergency response are compounded by construction of housing and commercial, industrial, and public facilities in flood-prone areas without adequate protection. Rural areas, which have limited development, are ideal for implementing nonstructural flood damage reduction measures since implementation can be accomplished without the major disruption of life which would occur in urban areas. However, those property owners in rural areas who are impacted would experience major disruptions in their lives and livelihood for which they are generally compensated. The high cost of relocating people and facilities out of the floodplain can also be minimized. In areas where it is not economically feasible or appropriate to provide structural flood management measures, nonstructural measures should be considered which encourage the use of the flood-prone areas that are compatible with the flood threat. Future flood damages would be reduced and ecosystem restoration and preservation would be likely.

Description of Measure: Nonstructural floodplain management measures include zoning regulations to control development; flood proofing structures by raising or protecting with dikes; relocating damageable property out of flood-prone areas; acquisition of flowage easements; and installing flood warning systems. Some government agencies include setback levees, back-up levees, reservoir re-operation, bypasses, and transitory storage in the definition of "nonstructural measures." These measures are discussed separately, later in this appendix.

Implementation of nonstructural floodplain management measures necessitates that the nature and extent of flood prone areas be accurately defined. Effective floodplain management and regulation must be enacted. Public officials must be informed of the specific nature of the flood threat in their areas. Public officials and private citizens must be cognizant of wise, safe floodplain management practices.

Objective(s) Addressed by Measure:
- Avoid or reduce potential future flood damages by communicating residual flood risk throughout the flood management systems.
- Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.
- Compensate for unavoidable adverse socio-economic, land-use, and environmental impacts associated with flood management actions.
- Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management systems using an ecosystem approach.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Implement improved floodplain management policies consistent with recommendations made by the FEAT Task Force on Flood Plain Management.
- Improve other beneficial uses related to flood damage reduction.

Benefits of the Measure: Flood damage reduction and ecosystem restoration would result from encouraging uses of the floodplain which are compatible with the flood risk. The establishment of natural river processes would create a more natural river environment with a diversity of habitat along the river.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): The development of nonstructural floodplain management practices in rural areas necessitates the implementation and enforcement of land use ordinances by local entities that restrict land use to those commensurate with the flood risk. A program also must be developed that includes financial incentives for landowners to practice safe nonstructural floodplain management. Floodplains for rural areas must be developed in a way which procures support from local, State, and Federal agencies. Landowners must know the extent and nature of flood risk to their land without the confusion that occurs when different agencies promote differing floodplain designations. Implementation of nonstructural floodplain management in rural areas could conflict with agricultural practices such as bedding up fields, fall pre-irrigation, and land leveling; with re-routing natural sloughs to accommodate change in land use; and with existing County grading ordinances and criteria/regulations on land development.

Measure: Revise Floodplain Management Policy -- Mandatory Flood Insurance for Structures Subject to Residual Risk

Background: No levee is 100 percent safe. Levee failures can occur during flood flows at/or below design levels and levees can also be overtopped during storms much larger than those for which the flood protection system was designed. So when development takes place in areas protected by levees, structures are still at risk of flooding. Currently, if a levee has been "certified" (by FEMA or the Corps) to provide 100-year flood protection, flood insurance is not required for structures in such areas because for insurance purposes these structures are considered to be outside of the 100-year floodplain. However, residents living behind levees should be considered by the community to be exposed to some risk of residual flooding. Homes protected by levees can be inundated if the levee fails; if a flood larger than the 100-year flood occurs; or if the hydrology changes. Many communities and most property owners do not realize how serious is the risk of flooding behind levees.

Description of Measure: A 100-year level of protection for structures in rural and agricultural areas is probably sufficient; but in urban areas where structures are more concentrated, a minimum of at least a 200-year, and perhaps up to a 500-year, level of protection should be provided. The appropriate level is a function of how highly urbanized the community is, the level of risk for rapid, deep inundation, and other factors. Requiring flood insurance for structures protected by levees would be a way to reduce the property owners' financial risk. One way to accomplish a mandatory flood insurance requirement for structures protected by levees would be to incorporate this requirement into as part of the NFIP. A requirement to purchase flood insurance would be an additional cost to residents who may not now be required to have flood insurance. The NFIP currently provides a reasonably priced "preferred risk" policy that could be tailored to fit the requirements of levee protected areas. The purchase of mandatory flood insurance raises public awareness of the risk of living in areas protected by levees. This could result in better-planned developments and construction of higher standard levees, the consequence of which is to reduce flood damage and lower expenditures of State and Federal disaster assistance funds. Improved awareness of the risk could also encourage better levee maintenance practices, and those communities participating in the Community Rating System (CRS) can earn additional credits and resulting discounts to flood insurance premiums for exceeding the minimum NFIP criteria.

Objective(s) Addressed by Measure:
- Avoid or reduce potential future flood damages by communicating residual flood risk throughout the flood management systems.
- Avoid or reduce potential future flood damages by increasing community awareness of the flood risk associated with areas protected by levees.
- Improve coordination of floodplain management activities among local, State and Federal entities.
- Prevent, or reduce, future financial hardship on property owners by adopting mandatory flood insurance for areas protected by levees.

Benefits of the Measure: Mandatory flood insurance for areas protected by levees would focus attention on the residual risk involved with levees, and could lead to improved levee standards and maintenance. Reduced flood damage; reduced adverse socio-economic impacts on communities; lessened traumatic effects of the loss of personal, irreplaceable items; and reduced State and Federal flood disaster assistance payout could result from this measure. Mandatory flood insurance would help to reduce disruption to local economies, and also serve as an example to encourage FEMA to modify the NFIP to include national mandatory insurance.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Some property owners may be opposed to the concept of mandatory flood insurance, but the financial burden on the property owner in the event of a flood would be lessened. Where communities exceed minimum NFIP criteria they may qualify for community reductions in flood insurance premiums through the Community Rating System program.

Measure: Re-forestation of Floodplain Corridors

Background: The river basin floodplains once supported vast riparian woodlands along the major rivers. Historical maps and accounts indicate the existence of a continuous corridor of forests up to 5 miles wide along the Sacramento River, plus extensive forests on high terraces even farther from the river. Pre-settlement estimates of riparian vegetation along the Sacramento and San Joaquin Rivers range from 1,800,000 to 2,000,000 acres, not including the extensive forests along some tributaries. These vast connected woodlands supported many species and were a healthy, robust ecosystem that allowed the easy migration of species up and down the basins. Perhaps the most drastic difference between the historic condition and the present is the lack of a lush, unbroken riparian corridor forest. Most riparian forests were destroyed and fragmented by development, agriculture, and harvesting for firewood and construction. The construction of levees and the continued protection of those levees from erosion were significant causes in this reduction and continue to impact the greatly reduced riparian areas. Revetment and levee maintenance practices prevent the restoration of vegetation in the floodplain corridor. This reduction and fragmentation of riparian corridors has taken a tremendous toll on the ecosystem of the Sacramento and San Joaquin River basins and is a key cause in the listing of many of the species that are endangered or threatened.

Description of Measure: This measure would involve the restoration of vegetation in a continuous corridor along the mainstem rivers and tributaries. This could be accomplished in many ways. Maintenance practices could be revised to curtail the removal of naturally establishing vegetation. Plantings could be done on the river banks, berms, and waterside of levees. Plantings might also occur in flood bypasses. The width of corridor would have to be established based on biological need and might vary along the river, but optimum width would probably range in the hundreds of feet. Easements on agricultural land could be acquired and that land allowed to convert to native riparian vegetation. In some cases levees might have to be removed or set back to allow reforestation to occur. In all cases, the flood-carrying capacity would need to be preserved.

Objective(s) Addressed by Measure:
- Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management system using an ecosystem approach.
- Promote the stability of native species populations and recovery of threatened and endangered species in the flood management system.
- Minimize flood management system operation and maintenance requirements and associated costs.

Benefits of the Measure: Reforestation would help to restore the riparian corridor that once existed. Historic conditions could never be achieved and that would not be the goal of this measure. This would be a significant improvement in the ecosystem and could aid the recovery of many special status species. A continuous riparian corridor would aid the restoration of important floodplain functions such as corridors for species migration, habitat for reproduction and feeding, and barrier and filtering of contaminants and sediments. Vegetation on the banks of streams can also provide erosion resistance and could reduce the need for structural erosion protection.

Physical, Operational, or Institutional Considerations (conflicts and resolutions):
Many believe the planting of trees on levees will diminish its structural integrity. This is the reason for the maintenance practices in force today. However levees can be enlarged (over-built) so that reforestation on levees is less of a structural risk. The levee enlargement would require additional land and some possible relocation of facilities. Re-forestation in floodplain corridors can also impact conveyance of the floodplain and increase elevations for the same floodflow thus increasing the risk of flooding to adjacent lands. Where the corridors are leveed, the capacity of the flood management system is carefully protected. Any measure which impacts that conveyance would have to mitigate for that impact by either raising the levees are by providing additional flood storage. This measure could be combined with other measures such as set back levees to result in no impacts to the flood management purpose and benefits for both purposes. Re-forestation can attract special status species with resultant restrictions placed on adjacent land operations. This results in many adjacent landowners resisting re-

forestation measures. The USFWS has been working on criteria for safe harbor-type agreements which would protect adjacent land owners from restrictions due to the presence of special status species. Agricultural interests resist the conversion of agricultural lands. Where existing agricultural lands ere proposed for conversion to riparian forests, the landowners would have to receive appropriate compensation. Secondary impacts due to agricultural conversion would have to be investigated and appropriate compensation considered. In some cases, flow regimes restrict the success of re-forestation efforts. If this were the case, changes in reservoir operations would have to be considered to improve re-forestation success.

Measure: Protect Existing Natural Physical Processes

Background: Climate and geology are the principal factors controlling stream flow. They modify channel discharge, location, morphology, gradient, and sediment load. Since climate and geology vary with location and time, the physical features of rivers and their floodplains are inconstant and unstable, often changing dramatically within hours or days.

Rivers transport water through a watershed, but they also work as sediment conveyors, transporting materials eroded from the upper reaches and depositing them in the lower ones. While transporting sediment, rivers form point bars on the inside (convex side) of channel bends. On the outside (concave side) of the bends, rivers erode channel banks. The combination of erosion of outside bends and deposition on point bars results in channel migration. Channel movement is often incremental, and the river bends gradually move downstream.

Over time, the processes of erosion, deposition, and channel movement create an alluvial floodplain. When floodwater discharge is greater than the capacity of the channel, rivers overflow their channels and inundate portions of the floodplain.

Riparian areas are adapted to disturbance of channel and floodplain areas. Riparian plants colonize new sediment deposits, and once established, modify and inhibit water flow and promote the deposition of additional sediment. The processes of erosion, transportation, and deposition of sediment are closely linked with the physical location and biological characteristics of historical and current riparian forests.

Californians originally constructed levees along major rivers and tributaries to control floods, to maintain summer flows deep enough to accommodate river navigation, and to move hydraulic mining debris by confining the channel to promote scouring. The levees were set close together to restrict river channel width. Levees reduced flooding of adjacent floodplain areas, and thus allowed agricultural and urban development of land adjacent to rivers.

To protect and stabilize levees, bank protection was placed on levee surfaces along the outside of river bend, thereby reducing erosion. These "hard points" may change the rate and pattern of channel movement, upstream and downstream. When the channel migration process is stopped in place at one bend by bank protection, the bend downstream or across the river may erode more rapidly than it would have otherwise.

Construction of major reservoirs on most of California's major rivers also modified the natural physical processes of rivers. During major flood events, upstream reservoirs intercept and store initial surges of runoff, regulating floodflow releases to downstream leveed streams, enlarged channels, and bypass floodways, and releasing water once floodflows have declined. Upstream reservoirs also store runoff in winter and spring, and divert the water to agricultural and urban water users.

As a result of engineered modifications to the rivers of the study area, riparian habitat has been eliminated or adversely affected.

Description of Measure: Modify flood flow releases to increase flow variability and provide high peak flows of short duration. Reserve some flood flows for release during seed release periods of riparian trees in spring and to maintain high groundwater elevations in channel and floodplain areas in late spring and summer.

Preserve and improve river use of floodplain areas to permit channel changes such as creation of new channels, changes in channel location, and river meandering. Allow rivers to scour channel areas, erode banks, and deposit sediment in bars.

Objective(s) Addressed by Measure:
- Improve system reliability.
- Minimize operation and maintenance requirements of the flood management systems and associated costs.
- Create additional riparian, wetland, and shaded riverine habitats system-wide and improve habitat diversity, spacial distribution, and age class.
- Contribute to threatened and endangered species recovery throughout the systems.
- Contribute to the restoration/rehabilitation of a dynamic system (natural hydrologic, geomorphic processes) to the extent practicable.
- Incorporate ecosystem restoration into the design of elements of the systems.
- Improve the dynamic hydrologic and geomorphic precesses to help sustain, enhance, and regenerate riparian and floodplain habitats.
- Reduce potential damage to the river systems from gravel pit captures

Benefits of the Measure: Setting aside floodplain areas for physical processes can improve system reliability, reduce costs for new flood damage reduction facilities, and reduce maintenance costs for existing facilities. Providing floodplain space for physical river processes may increase channel capacity and/or attenuate large floodflows. Re-establishing suitable hydrologic regimes, protecting and providing floodplain space for physical river processes, and regulating flows during seed dispersal periods of early successional species will aid the establishment of riparian habitat and species. Fostering establishment of riparian habitat and species may minimize environmental regulatory processes for maintenance of flood damage reduction.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Modified flow releases could limit reservoir operation flexibility in early to mid-winter months. Modified flow releases could cause impacts from inundation, erosion, or sedimentation to urban and/or agricultural areas and to infrastructure such as buildings, roads, bridges, water diversion points, and levees. Setting aside floodplain areas for river physical (geomorphic) processes may remove some parcels from agricultural use.

Floodplains now contain urban development, agricultural fields, or infrastructure and levees. These locations must be protected from inundation, erosion, and sedimentation. Flows in many areas are highly regulated to avoid exceeding channel capacity or to divert water to other uses, thereby limiting the water available for the physical processes in the river and floodplain. To achieve the maximum benefits of flood damage reduction and water supply reservoirs, specific downstream channel capacities must be maintained. Areas selected for protection of natural physical processes must have the appropriate hydrological and geological features that will produce channel changes; they should also possess existing riparian vegetation or be adjacent to existing riparian vegetation areas. Protecting existing natural physical processes to promote natural restoration may require the control of invasive or weedy species. Any riparian habitat management must be coordinated with the flood management agencies.

Measure: Re-establish Suitable Hydrologic Regime to Restore Natural Physical Processes

Background: The natural physical process for a river in an alluvial floodplain is one of erosion, deposition and plant succession. Rivers are dynamic and historically have meandered across a broad floodplain. This results in constantly shifting areas of erosion and deposition in the outside and inside of meander bends respectively. In the deposition areas vegetation establishes and through succession over the years riparian forests are formed. A major driver of this process is the hydrologic regime of the river course. Flows in the river are the force for erosion, sediment transport, and deposition. Dam construction and their modification of the hydrologic regime have greatly reduced this process. This has resulted in a significant diminishment of this process with the result that old established riparian forests are dying out or being removed without regeneration occurring to replace them.

Description of Measure: This measure would involve the modification of releases from the reservoirs in the system. Release rules would be revised to insure that flows were high enough for a duration long enough to move significant sediment in the river. Most falls, reservoirs must release stored water in order to provide the authorized flood storage for the flood season. This would be a very opportune time to increase the release rate. However it would be the wrong time for seedling establishment. In the spring most reservoirs are filling for summer water supply storage and unless there is a significant snowpack, adequate excess water might not be available for high releases. Each system would require analysis to determine what flow magnitude was required to move significant sediment.

Objective(s) Addressed by Measure:
• Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management system using an ecosystem approach.
• Promote the stability of native species populations and recovery of threatened and endangered species in the flood management system.
• Promote natural, dynamic hydrologic and geomorphic processes in the flood damage reduction system.

Benefits of the Measure: Re-establishment of natural physical processes would help to restore the riparian corridor that once existed. Historic conditions could never be achieved and that would not be the goal of this measure. This would be a significant improvement in the ecosystem and could aid the recovery of many special status species. A continuous riparian corridor would aid the restoration of important floodplain functions such as corridors for species migration, habitat for reproduction and feeding, and barrier and filtering of contaminants and sediments.

Physical, Operational, or Institutional Considerations (conflicts and resolutions):
Some reservoirs may not have the outlet capacity to provide the release magnitude required for significant sediment movement. This would require structural modification to those structures to increase their release capacity. If the high flows were required in the spring, higher release rates might impact water supply storage. Water purveyors would be due compensation for that water lost for water supply. It's possible that the high releases could be done in the fall when more water is available to establish the physical structure that would still be available in the spring for plant establishment. These higher releases would have to be closely coordinated to ensure that the larger releases down each tributary did not overwhelm the levee system of the mainstem. This might require that not all reservoirs make the higher releases at the same time. This natural physical process involves erosion of the bank. Those landowners losing land to erosion might not support this measure unless they were compensated for their losses.

Measure: Restore Oxbows

Background: In the Central Valley, there is a limited availability of quality backwater habitats, including associated seasonal and permanent wetlands and riparian forest. These habitat types are vital for many species of fish and wildlife. Historically, oxbow lakes and sloughs provided valuable backwater habitat. Construction and operation of the flood management systems and the conversion of floodplains to agriculture and urban uses have permanently isolated oxbows from receiving even periodic moderate or high flows from the river. As a result, the value of these areas as backwater habitats has declined.

Description of Measure: Reconnect abandoned oxbows to the adjacent river. At abandoned oxbows with flat gradients, grade small areas to allow flooding during high and moderate flows. In other areas, dredge new channels and breach the levee to reconnect the oxbow. Natural processes would establish seasonal wetland, permanent wetland, and riparian forest communities. Plant establishment could be accelerated by planting some species, like tules, sedges, willows, and cottonwoods.

Study Objective/s Addressed by the Measure:

- Protect and restore riparian, riverine, and wetlands habitats system-wide
  - -Increase and improve riparian, floodplain, flood basin, and riverine habitat using an ecosystem approach.
  - -Promote the stability of native species population, and the recovery of threatened and endangered species in the flood management systems.
  - -Incorporate ecosystem restoration features into the design of Federal, State, and local elements of the flood management systems.

- Reduce flood damages, risk of levee failure, and maintenance
  - -Reduce the risk to lives and property by improving system reliability.
  - -Improve other beneficial uses related to flood damage reduction.

Benefits of the Measure: This measure would expand productive habitats for waterfowl and perching-birds, including sensitive species like the yellow-billed cuckoo. It would also provide essential habitat for amphibians. Riparian forests established in association with the oxbow would provide valuable SRA habitat. This habitat could provide shading necessary to reduce instream temperatures vital for the survival of winter-run chinook salmon. In some areas, the reconnected oxbow could provide year-round rearing habitat for steelhead and Chinook salmon. The oxbows would also provide substantial addition of invertebrates and organic matter to the river ecosystem.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): There may be some engineering difficulties in effectively reconnecting oxbows with the main channel. Public health and nuisance concerns must be addressed in developing backwater habitats. For example, project planning would need to consider designs to minimize mosquito production. Any potential habitat restoration activity in the floodplain should account for private property rights, public trespass, potential endangered species and wetlands regulatory actions, and local government concerns about loss in tax revenue.

Measure: Restore Spawning Gravel - Replenish Gravel

Background: Gravel is important for maintaining spawning habitat for anadromous fish, including federally protected species. Anadromous fish prefer clean loose gravel. Gravel size and areal extent suitable for spawning habitat vary by species. Gravel also supports the many invertebrates on which young salmon and other species prey.

Gravel recruitment is limited by dams which block downstream gravel transport; bank protection; and gravel mining on tributaries. In some areas where spawning gravel may be adequate to support current salmon and steelhead populations, gravel replenishment would be necessary to support future population increases.

Description of Measure: Replace spawning gravel by placing large quantities of gravel in key locations along the mainstem and tributaries to support anadromous spawning. Gravel is distributed downstream through natural processes during high flows. This measure is generally performed in stream reaches below dams where natural recruitment of gravel has been eliminated.

Objective(s) Addressed by Measure:
- Protect and restore riparian, riverine, and wetlands habitats system-wide.
- Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management systems.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood damage reduction systems.

Benefits of the Measure: Increase in scarce spawning habitat for anadromous fish, including some Federally protected species. Increase in diversity of aquatic habitats to benefit numerous fish and invertebrate organisms, and to increase the productive capacity of the river.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Unknown benefit to flood damage reduction. Large flood events could displace replenished gravel, thus creating an on-going program of gravel replenishment to ensure continued availability of spawning gravel at key locations.

Related Measures
- Restore spawning gravel - upstream land management
- Restore anadromous fish rearing habitat.

Measure: Restore Spawning Gravel - Upstream Land Management

Background: Substrate composition is a critical factor in the suitability of a section of river for anadromous fish spawning. The fish require clean loose gravel that remains stable during incubation and emergence. Substrate composition must be low in sand and fines so that its permeability to water allows successful incubation and emergence of the juveniles.

Suitable spawning habitat has decreased in recent decades. In some areas, there is insufficient suitable spawning habitat to support existing fisheries. In other areas, existing spawning habitat is insufficient to support expanded fish populations. Gravel recruitment is limited by dams which block downstream gravel transport, bank protection, and gravel mining on tributaries. Land management practices that contribute to erosion may cause silts and sands to enter the streams and rivers and degrade the quality of spawning gravels.

Description of Measure: This measure has two elements. The first element entails protection of natural recruitment from tributary streams to ensure that the gravel deficit does not worsen. The second element concerns upstream land management that contributes to erosion, and would be altered or mitigated. A comprehensive, watershed approach would be necessary.

Objective(s) Addressed by Measure:
- Protect and restore riparian, riverine, and wetlands habitats system-wide.
- Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management systems.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood damage reduction systems.

Benefits of the Measure: Protection of spawning habitat for anadromous fish, including some Federally protected species. Increase in diversity of aquatic habitats to benefit numerous fish and invertebrate organisms, and to increase the productive capacity of the river.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Unknown benefit to flood damage reduction. Alternatives to bank stabilization may require additional lands (berms on levees for vegetation and river meander). These alternatives may not be as tested as commonly used bank stabilization. Upstream land management is largely outside the jurisdiction of the Corps; in a single watershed it would likely involve Federal, State, local and private lands. Numerous Federal and State regulations exist to address land management.

Measure: Remove Exotic Vegetation - Terrestrial

Background: Plants that are not native to California have become established within natural ecosystems. Such plants are known as exotic plants. Problem exotic plants in the Central Valley include giant reed (*Arundo donax*), Himalayan blackberry (*Rubus discolor*), salt cedar (*Tamarix chinensis*), Tasmanian blue gum (*Eucalyptus globulus*), edible fig (*Ficus carica*), and black locust (*Robinia pseudoacacia*). These plants are often more tolerant of human activities and disturbed and altered environments than are native plants. Adaptations allow these highly invasive plants to successfully compete with native plants include the production of large numbers of seeds, fast growth, and the ability to propagate from small pieces of plant. In addition, exotic plants frequently lack natural predators, diseases, or completing plants.

Exotic plants compete with native plants for water and other resources. Plant communities dominated by exotic plants provide fewer habitat values to wildlife than do native plant communities. These invasive plants also encroach into the floodway, spread quickly, and form dense stands, thereby obstructing flood flows.

Description of Measure: Develop a comprehensive program to remove and control woody exotics. Measures would include replacement plantings with native plants which are consistent with flood management objectives.

Objective(s) Addressed by Measure:
- Protect and restore riparian, riverine, and wetlands habitats system-wide.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Improve management throughout the systems.
- Reduce the risk to lives and property by improving system reliability.
- Reduce the risk of catastrophic flooding to urban areas.
- Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.

Benefits of the Measure: The measure would increase habitat for small mammals, and for resident and migratory birds. In areas with large stands of exotic vegetation, their removal could increase channel capacity.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Successful implementation is likely to require a new, long-term program.

Related Measure(s):
- Remove Exotic Vegetation - Aquatic
- Measures related to in-channel sediment removal.

Measure: Remove Exotic Vegetation - Aquatic

Background: Non-native aquatic plants compete with native aquatic plants for resources and space. Some non-native plants reproduce and spread rapidly, forming dense mats that choke waterways. These plants reduce the value of the waterway as habitat for fish and wildlife, diminish flood conveyance capability of the waterway, and reduce the accessibility of the area for water-based recreation like boating, swimming and fishing. Flood conveyance capability is also reduced.

Description of Measure: Develop a comprehensive program to remove and control exotics like water hyacinth.

Objective(s) Addressed by Measure:
- Protect and restore riparian, riverine, and wetlands habitats system-wide.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the flood management systems.
- Improve management throughout the systems.
- Reduce the risk to lives and property by improving system reliability.
- Reduce the risk of catastrophic flooding to urban areas.
- Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.

Benefits of the Measure: The measure would increase habitat for fish, waterfowl, shorebirds and other species that require access to the waterway. In areas with large stands of exotic vegetation, their removal would increase channel capacity and increase recreation access.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Successful implementation is likely to require a new regional long-term program. The Department of Boating and Waterways' hyacinth control program, which currently focuses in the Delta, might be expanded into other Central Valley waterways.

Related Measures:
- Remove Exotic Vegetation - Terrestrial.
- Measures related to in-channel sediment removal.

Measure: Restore Gravel Pits

Background: Sand and gravel are used as construction aggregate materials. Sand and gravel suppliers often mine gravels from river channel or adjacent floodplain areas. Mining from the channel alters channel elevation and geometry, often causing channel incision and headcut erosion of pits. Channel pits created during mining also trap bedload sediment during high flows, and accelerate downstream sediment loss as flows reacquire sediment.

Mining operators often leave only thin strips of unmined land between channel areas and floodplain mining pits. Flood flows often cause channel migration that breaches levees or strips of land separating the channel from floodplain mining pits. Recaptured floodplain pits change the course of channels and trigger channel elevation and geometry changes, erosion, and sediment budget changes.

Floodplain gravel pits eliminate riparian and agricultural areas. Since floodplain pits are usually steep-sided, they often provide limited potential for development of wetlands.

Channel pits often cause extensive channel modifications that can disorient migrating juvenile salmon. Pits also provide favorable habitat for warm-water fish such as largemouth and smallmouth bass, which prey on juvenile chinook salmon.

Description of Measure: Segregate channel areas from floodplain gravel pits by repairing or maintaining separation strips and levees between channel and floodplain strips. Refill pits where feasible. Modify pit sides to provide gently sloped banks for wetlands and irregular shorelines for better habitat diversity. Vary pit depth to provide habitat diversity.

Objective(s) Addressed by Measure:

- Promote natural, dynamic hydrologic and geomorphic processes in the flood management system.
- Increase and improve riparian, floodplain, flood basin, and riverine habitat throughout the flood management system area.
- Promote recovery of threatened and endangered species and the stability of native species populations in the flood management system area.
- Develop tools to analyze the hydrologic, hydraulic, geomorphic, and biologic processes of the flood management system.
- Promote the stability of native species populations.

Benefits of the Measure: Modifying pit edges will increase the extent and quality of wetland habitat. Refilling pits will create potential riparian and wetland habitats. Reducing habitat for anadromous fish predators and reducing complications for anadromous fish will promote native fish species populations, including some federally protected species. Reducing river reaches disturbed by gravel pits will increase the diversity and extent of aquatic habitats for numerous fish and invertebrate organisms and increase the productive capacity of the river.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Refilling or modifying floodplain pits may temporarily eliminate wetland habitat. Refilling or segregating pits from channel areas may reduce recreational fishing opportunities for some fish species. Repairing and maintaining channel-pit separations will require construction and future maintenance activities that will cause short-term impacts to water quality and plant, wildlife, and fisheries resources.

Measure: County Protection of Stream Corridors

Background: Urban development within and adjacent to stream corridors not only places people and property at increased risk of damage from flooding, but also disrupts the structure and functioning of the corridor. In 1995, the population of California was 32.1 million. Projections estimate that the State's population could increase by about 50 percent to 47.5 million by 2020. The population of the Central Valley is expected to increase by 40 to over 100 percent. Without adequate planning, urban centers near rivers and streams are likely to encroach into adjacent stream corridors. Already an estimated 90 percent of riparian forests has been lost in the Central Valley. Urban development in and adjacent to stream corridors directly displaces riparian plant and animal communities, and this development disrupts the health of the ecosystem through an increased risk of man-made fire; garbage dumping; introduction of feral cats and dogs; and introduction of invasive exotic plants from residential gardens.

Description of Measure: Revise the State's flood management policy. Embody streamside/riparian protection in the general plan of each county. Restrict floodplain uses through zoning, or mitigate through insurance.

Objective(s) Addressed by Measure:
- Reduce the risk to lives and property by improving system reliability.
- Reduce flood damages related to insufficient system capacity.
- Reduce seepage and related damages on lands adjacent to levees.
- Improve system-wide coordination of floodplain management activities among local, State, and Federal entities.
- Improve other beneficial uses related to flood damage reduction.
- Increase and improve riparian, floodplain, flood basin, and riverine habitats throughout the flood management systems using an ecosystem approach.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood management systems.
- Reduce the impacts of past and current floodplain land use activities on hydrologic, geomorphic, and biological attributes of the river systems.
- Preserve agricultural productivity while promoting the ecological value of geoponic land.
- Incorporate ecosystem restoration features into the design of Federal, State, and local elements of the flood management systems.

Benefits of the Measure: Significant short- and long-term benefits to flood damage reduction and ecosystem restoration could be achieved by a well-planned, unified approach to protecting stream corridors through appropriate zoning and codification in county general plans and in the State's floodplain management policy.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Land use has historically been determined by local governments. There has been considerable resistance to proposals affecting land use that originate at the State or Federal levels. Land use choices are unlikely to leave the jurisdiction of local communities.

Measure: Increase the Acreage of Seasonal Wetlands

Background: Land reclamation and stream channelization for flood control have eliminated much of the historic seasonal wetlands in Central Valley. Reduction in the area of seasonal wetlands has reduced habitat value in several ways: reduced nutrient input into the aquatic ecosystem; reduced spawning and rearing habitat for some fish species; reduced groundwater levels with a resultant reduction in summer stream flows; and decreased diversity in wildlife habitat.

Description of Measure: Reconfiguration of areas adjacent to streams, channels, and bypasses to allow for seasonal wetlands. The objective would be to achieve an increase in: nutrient input in the aquatic ecosystem; groundwater levels; the quantity, quality, and frequency of use of seasonal wetlands by some fish species for spawning and rearing purposes; and the diversity of wildlife habitats.

Objective(s) Addressed by Measure:
- Reduce the risk to lives and property by improving system reliability.
- Reduce flood damages related to insufficient system capacity.
- Reduce seepage and related damages on lands adjacent to levees.
- Improve other beneficial uses related to flood damage reduction.
- Increase and improve riparian, floodplain, flood basin, and riverine habitats throughout the flood management systems using an ecosystem approach.
- Promote the stability of native species populations, and the recovery of threatened and endangered species in the systems.
- Promote natural, dynamic hydrologic and geomorphic processes in the flood management systems.
- Reduce the impacts of past and current floodplain land use activities on hydrologic, geomorphic, and biological attributes of the river systems.
- Incorporate ecosystem restoration features into the design of local, State, and Federal elements of the flood management systems.

Benefits of the Measure: This measure would provide benefits to terrestrial and aquatic species through an increase in habitat variety, quality, and quantity. It would be expected to enhance aquatic productivity. Specific benefits may include increases in: nutrient input in the aquatic ecosystem; areas and seasonal availability of flooded vegetation to be used as spawning and temporary rearing areas for species such as delta smelt and Sacramento splittail; diversity of wildlife habitats; vitality of adjacent and nearby wildlife areas; and groundwater levels in adjacent areas with a potential of increasing stream flows.

Physical, Operational, or Institutional Considerations (conflicts and resolutions): Potential negative effects of increased nutrient levels would require study and review by water quality professionals. Recreating seasonal wetlands to maximize use by fish and wildlife would require study and review by biological resource professionals. Other possible negative effects are: decreased availability of upland wildlife habitat; increased regulatory constraint on land management after the creation of wetland areas; crop damage from higher groundwater levels; problems for fish and wildlife from increased water temperatures; removal of land from taxation as a result of fee purchase by public entities; and loss of farmland in newly created wetland areas.